PATENT SPECIFICATION

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DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Improvements in or relating to Switch Controllers for Electrically Driven Vehicles

We, RANSOMES SIMS & JEFFERIES LIMITED, a British Company of Orwell Works, Ipswich, Suffolk, do hereby declare the invention for which we pray that a patent may be granted to us and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to electrically driven vehicles and is concerned more particularly with switch controllers for regulating the voltage across the armature or field of the electric driving motor, so as to regulate the speed of the vehicle.

Such switch controllers comprise a plurality of switches and actuating means adapted to be drivably connected to a speed control member of the vehicle, the actuating means being arranged to operate the switches or selected groups of the switches in succession upon movement of the speed control member in a direction to increase or decrease the speed of the vehicle. The switches are operable to connect different resistances in the electric circuit of the driving motor so as to vary the voltage across the motor, or to vary the voltage output of the electric supply, for example by connecting two or more sections of a battery either in series or in parallel. The voltage across the motor, and hence the speed of the vehicle, is thus variable in steps upon operation, in sequence, of the individual switches or groups of switches.

The electric circuit of an electrically driven vehicle is preferably arranged to provide a relatively large number of voltage steps across the motor, for example twelve steps, to enable the vehicle to be driven at or close to any desired speed within the speed range of the vehicle. This is particularly important with electrically driven vehicles which are required to manoeuvre in a restricted space, such as for example fork-lift trucks employed in factories and warehouses. The switch controller must have, of course, at least as many switches as the desired number of voltage steps. In addition the range of movement of the speed control member of the vehicle is preferably relatively small, for example, 60°, for convenience in operating the vehicle, but a too rapid build-up in voltage across the motor during acceleration must be prevented to avoid damage to the motor.

According to the invention there is provided a switch controller for electrically driven vehicles, comprising a frame, a cam rotor mounted in the frame for angular movement, a plurality of electric switches arranged in banks spaced axially along the cam rotor with the switches in each bank spaced circumferentially around the rotor, and rotary differential damper means coupled to the rotor for angular movement therewith, the cam rotor being adapted to operate in succession each of the switches or selected groups of the switches upon angular movement of the rotor within the frame, and the differential damper means being arranged to restrict the rate of movement of the cam rotor in one direction for operating the switches to increase the speed of the vehicle but permitting relatively free movement of the cam rotor in the reverse direction.

The improved controller has the advantages that it may have any desired number of voltage change switches, all of which may be operated in succession by the cam rotor upon movement of the rotor through a relatively small angle, the time interval between operation of individual switches by movement of the cam rotor in said one direction, and hence the rate of build-up of voltage across the motor, may be held within predetermined limits by the damper means, and the controller including all the switches and the damper means may be assembled in a compact structure.

At least some of the switches are preferably arranged in pairs in the banks, and a single cam step on the rotor is arranged to operate each switch of the pair of switches separately,

one after the other, upon angular movement of the rotor. The cam rotor can conveniently consist of a drum formed with cam steps spaced axially and circumferentially on the periphery of the drum, each cam step being adapted to operate separately, one after the other, two switches in one of the banks of switches.

The differential damper means preferably comprises a rotary dashpot co-axial with the cam rotor, the dashpot having valve means restricting the rate of angular movement of the cam rotor in one direction but permitting free angular movement in the opposite direction.

In an electrically driven vehicle fitted with the improved switch controller, the speed control member of the vehicle, which can conveniently be either a hand or foot operated lever, is preferably connected to the cam rotor by transmission means including a spring coupling arranged to urge the cam rotor in said one direction upon movement of the control member in a direction to increase the speed of the vehicle.

A switch controller according to the invention will now be described, by way of example with reference to the accompanying drawings, in which:—

Fig. 1 is an elevation view of the controller and linkage operating mechanism fitted on a bracket on the chassis of an electrically driven vehicle.

Fig. 2 is a part sectional plan view of the controller and linkage mechanism.

Fig. 3 is a view along the line III—III in Fig. 2.

Fig. 4 is a perspective view of the cam drum of the controller.

Referring to Fig. 2 of the drawings, the switch controller comprises a framework consisting of a back plate 10, a front plate 11, two annular switch plates 12, 13 disposed between and parallel to the back and front plates, two mounting bolts 14 extending through apertures in the plates 10—13, and four tubular distances pieces 15 mounted on the bolts 14, two of the distance pieces 15 being disposed on the parts of the two bolts between the switch plates 12, 13 and the other two distance pieces being disposed on the parts of the two bolts between the rear switch plate 12 and the back plate 10. The plates are clamped to the ends of the distance pieces by nuts 16 screwed on the bolts to form a rigid framework. The rear ends of the bolts 14 extend through apertures in a mounting bracket 17 on the chassis of the vehicle, and further nuts 18 on the bolts secure the framework to the bracket.

A "Kinetrol" differential rotary dashpot 20 is secured by bolts 21 to the back plate 10 of the controller framework, the rear portion of dashpot extending through apertures in the back plate 10 and the bracket 17. The construction of the dashpot is not illustrated, but is of the known kind having a vaned rotor adapted to displace oil through metering orifices upon rotation of the rotor in one direction, and one-way valves adapted to permit free flow of oil upon rotation of the rotor in the other direction. The rate of movement of the vaned rotor in said one direction is thus restricted, while movement in the other direction is relatively unrestricted. A splined shaft 22 on the vaned rotor extends forwardly through the housing of the dashpot and is arranged to serve as a support for a cam drum 23.

The cam drum 23 has a peripheral wall connected at one end by a radial flange 24 to a hub 25 disposed within the peripheral wall, and a bearing sleeve 26 is mounted in an aperture extending axially through the centre of the hub 25. The sleeve 26 is secured in position in the hub by a locating screw 27 (Fig. 3). The peripheral wall of the drum is formed with inclined cam steps 28 disposed three on each side of the drum. The three cam steps on each side of the drum are arranged end to end at 5 degrees radial intervals and extend along the full length of the drum, so that the peripheral wall has in effect two part-cylindrical portions of different external diameters. The peripheral wall of the drum at the centre of each part cylindrical portion is enlarged at the inside thereof and extends to the front of the drum to form cylindrical lugs 29, 30 for a purpose to be hereinafter described.

The cam drum 23 is arranged inside the framework of the controller with the rear end of the bearing sleeve 26 in the hub mounted on the splined shaft 22 of the rotary dashpot for rotation therewith. The cam drum is also supported by an adaptor 33 which has a central portion 34 and two stub shafts 35 of reduced diameter at the ends thereof. The rear stub shaft 35 is secured as a force fit in the front end of the bearing sleeve 26 in the hub of the cam drum, the front stub shaft 35 is rotatably mounted in a boss 36 on the front plate 11, and the central portion 34 of the adaptor acts as a spacer member between the hub of the drum 23 and the front plate 11.

Twelve micro switches 37 are arranged in three banks 38, 39, 40 spaced axially along the cam drum 23, with the four switches in each bank spaced circumferentially around the cam drum. The switches in the front bank 38 are bolted to the rear face of the front switch plate 13, and the switches in the other two banks 39, 40 are bolted in the front and rear faces respectively of the rear switch plate 12. Each switch has a spring steel operating finger 41 (Fig. 3) spaced from the body of the switch and movable against its own resilience towards the body of the switch to close contacts (not shown) in the switch. The finger 41 of each switch is fitted at the free end thereof with a roller 42 urged by the finger into rolling engagement with the periphery of the cam drum, so that upon rotation of the cam drum,

the rollers 42 ride over the cam steps 28 and move the operating fingers 41 to open or close the switches. The switches in bank 38 are operated by the cam steps on the front end portion of the cam drum 23, the switches in bank 39 are operated by the cam steps on the central portion of the cam drum, and the switches in bank 40 are operated by the cam steps on the rear portion of the cam drum.

The four switches in each bank are arranged in pairs on opposite sides of the cam drum, and the two switches in each pair are arranged with their operating fingers 41 extending in opposite directions towards each other so that their rollers 42 are adjacent. The switches in each pair of switches can thus be operated in succession by a single cam step upon movement of the cam drum through a relatively small angle.

The twelve switches 37 and the cam steps 28 are so arranged that, upon clockwise rotation of the cam drum through an angle of approximately 60 degrees from the position shown in Fig. 3, six of the switches are closed by the three cam steps 28 on one side of the drum 23 and the other six switches are opened by the three cam steps 28 on the other side of the drum 23, all twelve switches being operated individually in succession. Similarly, upon return movement of the cam drum, the closed switches are opened and the open switches closed individually in succession by the cam steps.

A terminal plug socket 43 for the electric conductors to the switches 37 is mounted on a lower extension 44 of the back plate 10 of the controller framework, and the framework is enclosed by a cover 45 secured to the front plate 11.

The speed of the vehicle is regulated by a pedal (not shown) in the driver's cab. The pedal is secured to one end of a Bowden cable 50 connected through a spring coupling 51 (Fig. 1) to the cam drum 23 of the controller, and the pedal is movable to pull the wire 52 of the cable through a flexible conduit towards the left as shown in Fig. 1.

The other end of the wire 52 on the Bowden cable is anchored by a clevis 53 to one end of a rocking lever 54 pivotally mounted intermediate its ends on a pin 55 secured on the bracket 17 on the vehicle chassis. The other end of the rocking lever 54 is coupled by a pivot pin 56 to one end of the spring coupling 51, and two pedal return springs 57 are tensioned between an anchor pin 58 extending through a lug on the bracket 17 and a further anchor pin 59 extending through the rocking lever 54.

The spring coupling 51 comprises a tube 61 having two end caps 62, 63 screwed onto the ends of the tube 61, an operating rod 64 slidably mounted in a bearing sleeve 65 secured in an opening in the end cap 62, and a spring 66 disposed between the bearing sleeve 65 and a head 67 on the end of the operating rod 64 within the tube 61. The end cap 63 is formed with a forked lug 68 in which is mounted the pivot pin 56 connecting the rocking lever 54 to the spring coupling.

The Bowden cable 52, the two pedal return springs, and the spring coupling are all arranged so that movement of the wire 52 of the cable to the left, as shown in Fig. 1, pivots the rocking lever 54 in an anticlockwise direction against the action of the return springs 57. This pivoting movement of the rocking lever 54 pulls the tube 61 of the spring coupling along the operating rod 64 in a direction to compress the spring 66 in the coupling, which spring then exerts a pull on the operating rod 64.

The end of the operating rod 64 remote from the spring coupling is connected by a ball and socket joint to the lug 29 on the cam drum 23, the socket being formed in a connector piece 70 secured to the end of the rod and the ball being formed on the end of a stud (not shown) screwed into a screw threaded aperture 71 in the lug 29. The front plate 11 and cover plate 45 of the controller are provided with openings 72 for the passage of the stud of the ball and socket joint, the openings 72 being large enough to permit angular movement of the cam drum through its 60° range of movement.

The operating rod 64 may be connected by a ball and socket joint to the lower lug 30 on the cam drum in a case in which the controller is mounted in a position relative to the spring coupling which is the reverse of that shown in Fig. 1.

When the vehicle is stationary, the spring coupling 51 is in its fully collapsed position with the head 67 of the operating rod 64 biased by the spring 66 against the end cap 63, and the cam steps 28 are disengaged from the rollers 42 on the operating fingers of the switches. When the pedal is depressed to start the vehicle the coupling tube 61 is pulled along the operating rod 64 and compresses the spring 66 in the coupling, as previously explained. The resulting pull which is exerted by the spring on the operating rod, is transmitted by the ball and socket joint to the cam drum 23 and tends to turn the drum in a clockwise direction. The rotary dashpot 20 however holds the rate of angular movement of the drum 23 below a predetermined limit, so that the drum only turns relatively slowly. Upon rotation of the drum, each of the switches 37 is operated in succession to increase the voltage across the motor in predetermined steps. The time delay between the operation of the individual switches is arranged so that, during acceleration, the vehicle approaches a speed corresponding to a particular voltage under steady running conditions, immediately prior

to the operation of the switch for connecting that voltage across the motor, so that the acceleration is fairly smooth.

The electric circuit for the motor can conveniently be arranged so that the first switch which is operated upon depression of the pedal to accelerate the vehicle from rest, closes the resistance circuit for the motor, and the second switch completes the main circuit to energise the motor. The third, fourth and fifth switches progressively short-circuit sections of the main resistance to cause an increase in voltage across the motor, and thereby an increase in speed. The sixth and seventh switches connect two parts of the main resistance in parallel, which results in a reduction of the total resistance and hence an increase in voltage across the motor. The eighth and ninth switches progressively short-circuit sections of the two resistances in parallel, and the tenth switch short-circuits all the resistance. The eleventh switch connects a resistance in parallel with the field windings of the motor, thereby increasing the speed of the motor, and the twelfth switch connects a further resistance in parallel with the field windings. The motor will then run at its maximum speed.

It is of course to be understood that the twelve switches in the controller do not transmit the main current for the motor, but control the usual relays and contactors which effect the main switching operations.

When the pedal is raised to decelerate the vehicle the end cap 63 on the coupling tube 61 engages the head 67 on the operating rod 64 and thrusts the rod back. The dashpot 20 permits free movement of the cam drum 23 in the decelerating direction, so that all the switches are then operated quickly in succession.

At intermediate settings of the pedal, the spring coupling sets the cam drum to an angular position corresponding to that of the pedal, the drum operating the switches for providing a speed corresponding to the setting of the pedal.

WHAT WE CLAIM IS:—

1. A switch controller for electrically driven vehicles comprising a frame, a cam rotor mounted in the frame for angular movement, a plurality of electric switches arranged in banks spaced axially along the cam rotor with the switches in each bank spaced circumferentially around the rotor, and rotary differential damper means coupled to the rotor for angular movement therewith, the cam rotor being adapted to operate in succession each of the switches or selected groups of the switches upon angular movement of the rotor within the frame, and the differential damper means being arranged to restrict the rate of movement of the cam rotor in one direction for operating the switches to increase the speed of the vehicle but permitting relatively free movement of the cam rotor in the reverse direction.

2. A switch controller as claimed in claim 1, wherein at least some of the switches are arranged in pairs in the banks, and the switches of each pair of switches are operable separately, one after the other, by a single cam step on the rotor, upon angular movement of the rotor.

3. A switch controller as claimed in claim 2, wherein each of the switches of said pair of switches has an operating finger, the free end of which is provided with a cam follower adapted to engage the cam step, the free ends of the two fingers extending in opposite directions towards one another whereby the cam followers are adjacent.

4. A switch controller as claimed in claim 1, wherein the cam rotor comprises a drum formed with cam steps spaced axially and circumferentially on the periphery of the drum, each cam step being adapted to operate separately, one after the other, two switches in one of said banks of switches upon angular movement of the drum.

5. A switch controller as claimed in claim 4, wherein said drum comprises two part-cylindrical portions of different external diameters, the junctions between said two portions being stepped axially to form said cam steps.

6. A switch controller as claimed in any of the preceding claims, wherein the damper means comprises a rotary dashpot co-axial with the cam rotor, the dashpot having valve means restricting the rate of angular movement of the rotor in said one direction but permitting free angular movement in the opposite direction.

7. An electrically driven vehicle fitted with the switch controller as claimed in any of claims 1—6 wherein a speed control member is drivably connected to the cam rotor of the controller by transmission means including a spring coupling arranged to urge the cam rotor in said one direction upon movement of the control member in a direction to increase the speed of the vehicle.

8. An electrically driven vehicle as claimed in claim 7, wherein said coupling comprises two telescopic members axially movable relative to one another, and a spring urging the two members into a telescopically contracted position.

9. A switch controller for an electrically driven vehicle substantially as herein before described with reference to the accompanying drawings.

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POOR QUALITY

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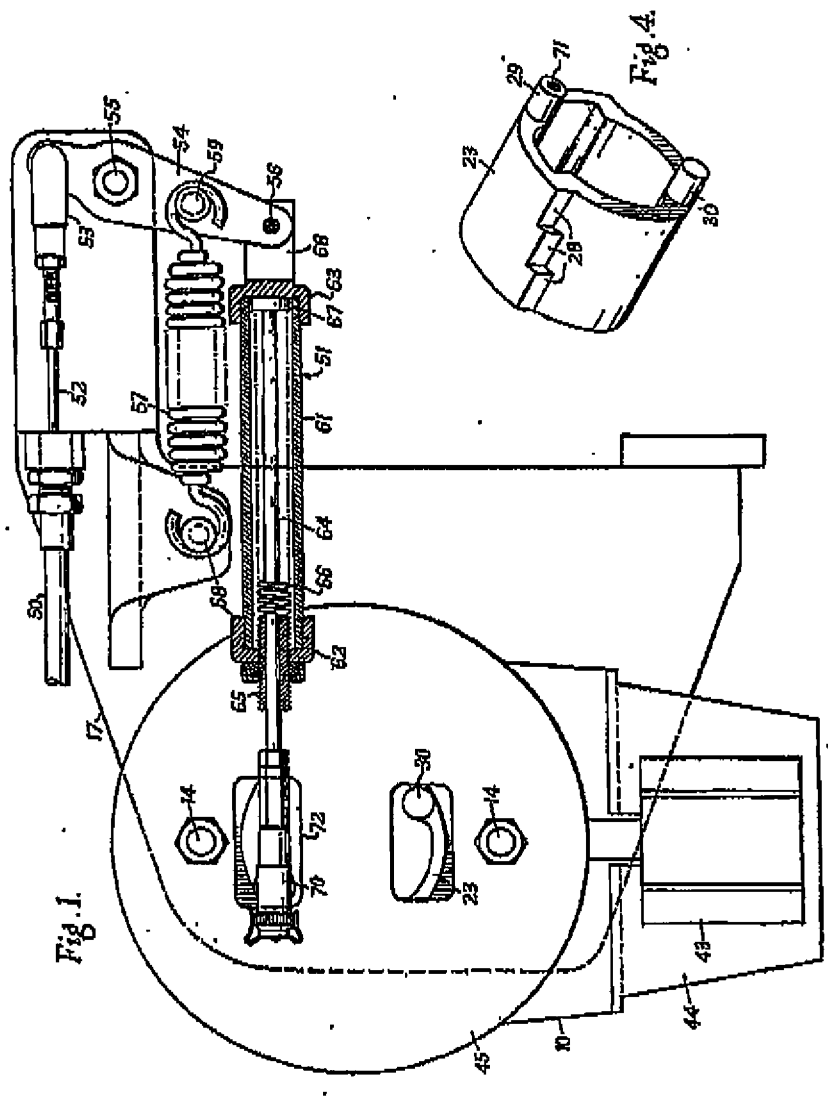

Fig.1.

Fig.4.

1052432 COMPLETE SPECIFICATION
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Sheet 2

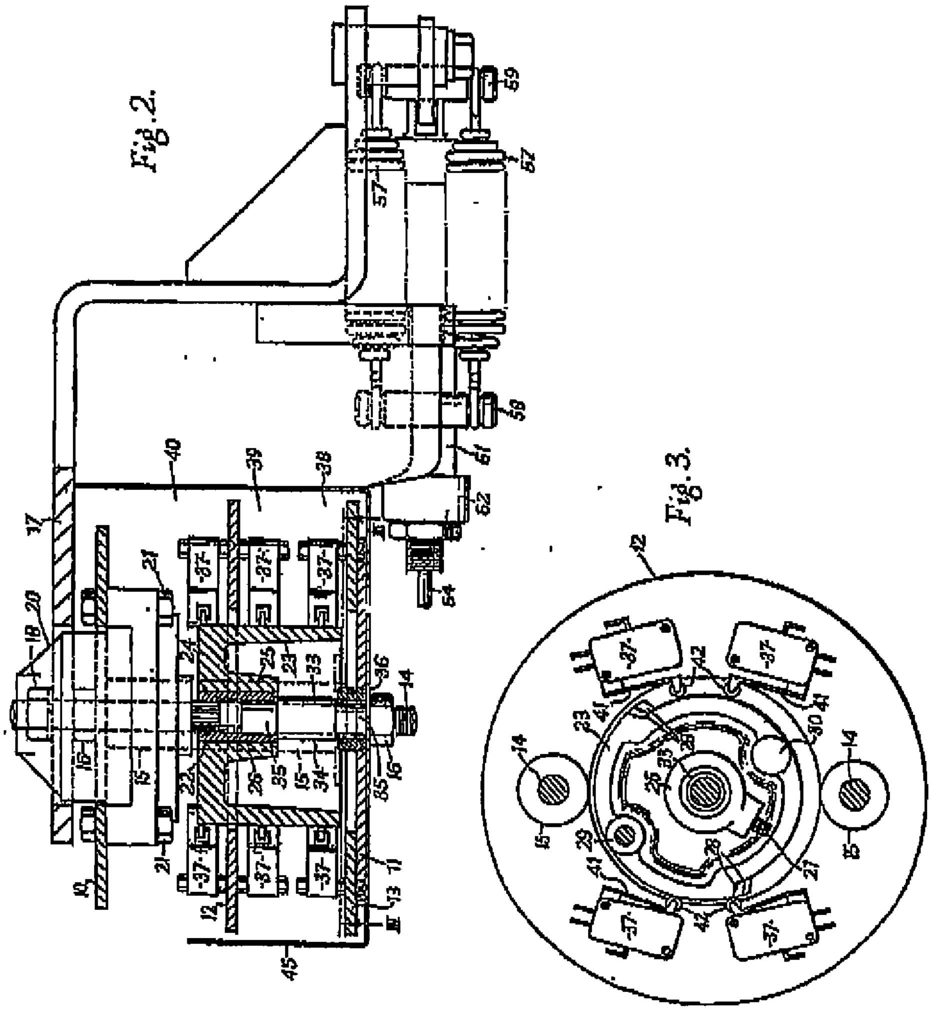

Fig. 2.

Fig. 3.